Oct. 1, 1940. A. MUTSCHELLER 2,216,209

DISCHARGE TUBE

Original Filed Dec. 10, 1937

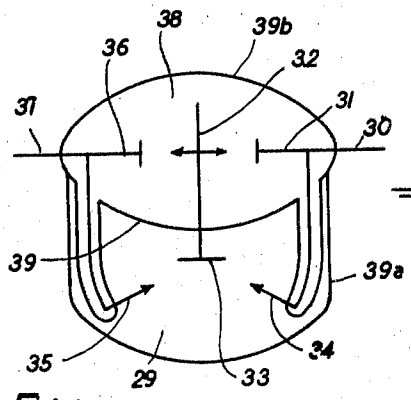


Fig.1

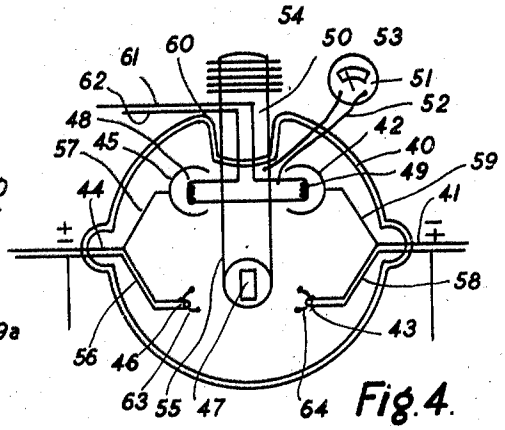


Fig.4.

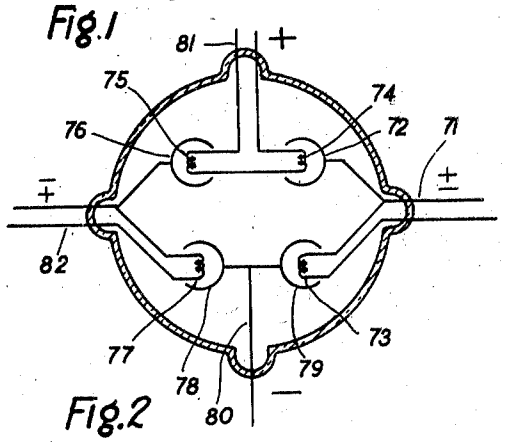


Fig.2

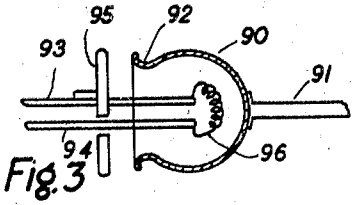


Fig.3

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DISCHARGE TUBE

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5 Claims. (Cl. 250—27.5)

This invention is for an improved high voltage current rectifier of the hot cathode type having many valuable features and advantages over the old known system of employing several single rectifier units for accomplishing the same result.

More specifically stated, I have discovered how a number of rectifiers of the high vacuum type can be combined into one unit and therewith the same result obtained as with the much more cumbersome and expensive old system in which several rectifiers must be interconnected, mechanically assembled and insulated from each other.

As an example, we have in the well known Graetz system for rectifying high voltage alternating current, a transformer having connected to each of its high voltage producing terminals two valve tubes one with its anode and the other with its cathode. The free anodes of these two pairs of valve tubes and also the free cathodes are connected together and from these then a high voltage pulsating unidirectional current is obtained. This kind of rectified high voltage current is usable for many purposes as for the excitation of X-ray tubes, dust precipitation, furnishing of plate voltage to radio circuits etc.

To obviate the requirement of connecting, supporting and insulating from one another of four and in some cases even more valve tubes, it would be obvious to combine them into one evacuated envelope and to obviate thereby many of the objectionable features for instance by reducing space, cost and the necessity of mounting so many separate rectifiers. But then serious difficulties are encountered which I have discovered how to eliminate and whereby a simple, small and in many other respects simplified single rectifier mounted in one envelope can be constructed.

Fig. 1 shows diagrammatically how, with a diaphragm of insulating material, and by operating at least one set of electrodes at voltage saturation the short-circuiting of electrons from one of the inlet electrodes directly over to the other can be prevented.

Fig. 2 shows, diagrammatically, how with specially constructed anodes alternating current can be rectified without the electrons short-circuiting from the cathode of one inlet terminal to the anode of the other inlet terminal.

Fig. 3 is a diagrammatic illustration of an anode and a cathode with which the escape of electrons to the outside of the cooperating anode is prevented.

Fig. 4 shows, diagrammatically, how an X-ray tube can be constructed in which both alternating current impulses are utilized for the production of X-rays and how the direct passage of electrons from one inlet electrode to the other has been avoided.

If electrons should directly traverse the evacuated space, for instance in Fig. 2 from cathode 77 to anode 72, then there could be no rectification as it is intended and the circuit through the discharge device would be short-circuited without delivering rectified current to the outlet terminals 80 and 81. Therefore, this direct transfer of electrons from one inlet terminal to the other must be prevented.

How this can be done is shown in the diagram Fig. 1, which shows two ways of preventing electrons from passing directly or short-circuiting for example from the cathode of one of the inlet terminals to the anode of the other inlet terminal. One way is to place the inlet cathode and anode in compartments separated by a septum or partition of dielectric material as here, the anodes 31 and 36 are on one side of the partition 39 and the cathodes 34 and 35 are on the other side of it. Therefore, instead of a direct discharge from cathode 35 to anode 31, or from cathode 34 to anode 36, the discharge must first be between cathode 35 and anode 33 then from cathode 32 to anode 31 or from cathode 34 to anode 33 and from cathode 32 to anode 36, and the current flowing in the outside circuit from anodes 33 to the cathodes 32 is then unidirectional.

The other way is to operate the discharge from cathodes 34 and 35 to the anodes 33 at voltage saturation and the discharge from the cathodes 32 to the anodes 31 and 36 below voltage saturation and therefore so that the electron emission from the cathodes 32 is larger than that from the cathodes 34 and 35 and that the voltage applied to the terminals 30 and 37 is sufficiently high to produce voltage saturation between cathodes 34 and 35 and the anodes 33.

In Fig. 2 and Fig. 3 a third way of preventing the direct passage of electrons between the cathodes and the anodes of the inlet terminals is illustrated. The anodes 72, 76, 78 and 79 are of special design so that even if operated below saturation, the direct passage of electrons from one of the inlet terminals to the other is prevented. These anodes are shaped to surround the cooperating cathodes to such an extent, that the negative potential on the lead-in wires to the emitting cathode which pass through the center of openings in the anode is sufficient to prevent the escape of electrons along the lead-in wires

and out of the enclosing anode. Thus the electron emitting cathodes 74, 73, 77 and 75 are "caged-up" within the receiving anodes 72, 79, 78 and 76 and the construction of the opening in the anode is so adjusted, that its diameter is smaller than the inside diameter of the anode. Still, if the anode is made tubular having a length dimension in the direction of the cathode lead-in wires greater than the diameter and closed at one end, it may not be necessary to make the opening for the cathode lead-in wires smaller than the lumen of the tubular anode.

In Fig. 2, two pairs of such anodes surrounding the cooperating cathodes are shown connected to form an alternating current rectifier which operates on the principle above outlined. The inlet terminals 82 and 71 receive alternating current impulses; the negative impulse from terminal 82 passes from cathode 77 to anode 78 out through outlet terminal 80 through an outside circuit back to inlet terminal 81 from cathode 74 to anode 72 to inlet terminal 71. Or, if terminal 71 is negative, the electrons pass from cathode 73 to anode 79 to outlet terminal 80, through an outside circuit back to terminal 81, from cathode 75 to anode 76 to inlet terminal 82. The opening in the anodes and the diameter of the cathode lead-in wires must be so adjusted, that if the voltage in the outside circuit is as large as that of the alternating current in-put, that no electrons can escape from the anodes that encage the cooperating cathodes.

How this is done is illustrated in the diagrammatic Fig. 3. The anode 90 supported on a stem 91 is spherical and provided with an opening having rounded and extended edges 92 which is smaller in diameter than the spherical anode. The cathode 96 is either a flat spiral, loops or a mushroom-shaped coil to leave a substantially equally spaced distance between the cathode and the anode. The cathode is supported by the lead-in wires 93 and 94 and a disc having rounded edges 95 may be placed so as to form an electrostatic shield to prevent electrons from escaping the anode. The enclosing anode, therefore, shields off all outside fields and the shield increases the electrostatic shielding effect of the cathode lead-in wires which are negatively charged so that no electrons can get out of the anode no matter how high the positive potential on the anode of the other inlet terminal may be.

The aforegoing description should serve to show, that there are numerous ways of preventing the direct passage of electrons from the cathode of one of the inlet terminals to the anode of the other inlet terminal which are connected to the alternating current source. Several of these have been described and illustrated. For instance by shielding with dielectric substance in Fig. 1; by operating, at least one pair of cathodes and anodes at saturation as is shown in Fig. 1, where the discharge from the cathodes 34 and 35 is controlled directionally with a focusing device 39 so that the discharge therefrom will fall upon an anode placed into the path of the accelerated cathode stream, and then adjusting the cathodes 32 to operate with the cooperating anodes below voltage saturation so that the voltage drop between these is less than the voltage drop between the cathodes 34 and 35 of the inlet terminals and the anodes 33; or the anodes may be formed to surround the electron emitting parts of the cathodes as shown in Fig. 2 and Fig. 3 to the extent that no electrons can be pulled out of the surrounding anode even if the voltage delivered into the working circuit in the form of unidirectional pulsating current impulses is equal to the voltage of the energizing alternating current. This same object may be obtained by providing a third or grid electrode having a voltage that prevents any electrons from escaping from within the anode through the opening through which the cathode lead-in wires are passing. All these are methods which in principle are well understood in the art and which any person skilled in this art can carry out successfully with these instructions without requiring further aid or instruction.

Having thus described several ways according to which my invention can be carried out, I hereby declare that other ways may exist with which the same results may be obtained and which may be substituted for those herein disclosed without having to do additional inventing.

Therefore, I claim,

1. An electric discharge tube comprising an envelope having therein a main anode having hollow electron receiving sections and a main thermionic cathode having electron emitting sections, an auxiliary hollow anode substantially enclosing each of said electron emitting sections, additional thermionic cathodes each being substantially enclosed by one of said hollow electron receiving sections, independent leads connected to said main cathode and to each of said auxiliary thermionic cathodes, a lead connected to said main anode, and a conductive connection between each auxiliary hollow anode and one only of said additional thermionic cathodes.

2. An electric discharge tube comprising an envelope having therein a main anode having electron receiving sections, and a main thermionic cathode having electron emitting sections, an auxiliary anode adjacent each of said electron emitting sections, additional thermionic cathodes being adjacent to said main anode and each having a focusing shield about each of said additional thermionic cathodes to direct the electron discharge therefrom upon the electron receiving sections of said main anode, independent leads connected to said main cathode and to each of said auxiliary thermionic cathodes, a conductive lead between said main anode and said main cathode and a conductive connection between each auxiliary anode and one only of said additional thermionic cathodes.

3. An electron discharge tube comprising an envelope having therein a main anode having electron receiving sections, and a main thermionic cathode having electron emitting sections, an auxiliary anode adjacent each of said electron emitting sections, additional thermionic cathodes each being adjacent said electron receiving sections, independent leads connected to said main cathode and to each of said additional thermionic cathodes, a lead connecting said main anode and said main cathode together, and a conductive connection between each auxiliary anode and one only of said additional thermionic cathodes, and a partition of dielectric material between non-adjacent electrodes as a shield against electron discharges between non-adjacent anodes and cathodes.

4. An electric discharge tube comprising an envelope having therein a main anode having electron receiving sections and a main thermionic cathode having electron emitting sections, an auxiliary hollow anode substantially enclosing each of said electron emitting sections, additional thermionic cathodes each being adjacent

one of said electron receiving sections and having a focusing shield for directing the electron discharge upon said main anode, independent leads connected to said main cathode and to each of said thermionic cathodes, a lead connecting said main cathode and said main anode together, and a conductive connection between each auxiliary hollow anode and one only of said additional thermionic cathodes.

5. An electron discharge tube comprising an envelope having therein a main anode having electron receiving sections, and a main thermionic cathode having electron emitting sections, an auxiliary anode adjacent each of said electron emitting sections, additional thermionic cathodes one adjacent each of said electron receiving sections, independent leads connected to said main and to each of said additional thermionic cathodes, a lead connected to said main anode, a conductive connection between each auxiliary anode and one only of said additional thermionic cathodes, there being means for preventing electronic discharges between said additional cathodes and said auxiliary anodes.

ARTHUR MUTSCHELLER.